SN 10/697,618

PTO 08-1314

CC=JP DATE=19930129
KIND=A PN=05021347

SPUTTERING DEVICE [Supattaringu Sochi]

Masaya Kobayashi

UNITED STATES PATENT AND TRADEMARK OFFICE
WASHINGTON, D.C. December 2007 TRANSLATED BY Schreiber Translations, Inc.

PUBLICATION COUNTRY	(10):	JP
DOCUMENT NUMBER	(11):	05021347

SN 10/697,618

DOCUMENT KIND	(12):	A
PUBLICATION DATE	(43):	19930129
APPLICATION NUMBER	(21):	H03-171200
APPLICATION DATE	(22):	19910711
INTERNATIONAL CLASSIFICATION	(51):	H 01 L 21/203C 23 C 14/3414/54
PRIORITY COUNTRY	(33):	N/A
PRIORITY NUMBER	(31):	N/A
PRIORITY DATE	(32):	N/A
INVENTOR(S)	(72):	Masaya Kobayashi
APPLICANT(S)	(71):	Canon, Inc.
DESIGNATED CONTRACTING STATES (81):		N/A
TITLE	(54):	SPUTTERING DEVICE

FOREIGN TITLE [54A]: Supattaringu Sochi

Patent Claims

Claim 1

A sputtering device which is a sputtering device designed, by oppositionally configuring a substrate & a target and by depositing, onto said substrate, constituent particles released from said target, to form a film and is characterized by the configuration of a variable mechanism designed to mount the aforementioned target for rendering the distance & angle of the aforementioned target in relation to the substrate to be adjustable.

Claim 2

A sputtering device which is the sputtering device mentioned in Claim 1 and is characterized by the facts that multiple targets are configured in opposition to said substrate and that at least one of said targets is mounted on an individually configured variable

mechanism.

Detailed explanation of the invention

[0001]

(Industrial application fields)

The present invention concerns a sputtering device designed to form a film by oppositionally configuring a substrate & a target and by depositing, onto said substrate, constituent particles.

[0002]

(Prior art)

A sputtering device is designed to form a film by depositing, onto a substrate, scattered constituent particles released from a target. The surface of this target becomes progressively depleted as a result of film formation actions, as a result of which the flight pattern of said constituent particles greatly varies; and the deposition rate & composition of the film formed above the substrate come to differ from their counterparts in the initial phase

of the film formation action. Attempts have been made in the prior art to prevent these changes by varying the electric power impressed onto a target and by accordingly adjusting the flight magnitude of said construction constituent particles.

[0003]

(Problems to be solved by the invention)

An attempt is thus made, for the purpose of preventing the variations of the deposition rates & compositions of films formed above substrates, by this sputtering device of the prior art to adjust the flight magnitude of constituent particles by varying the electric power impressed onto a target. Even if the flight magnitude of the constituent particles is thus varied, however, the scattering direction thereof remains unchanged, which is problematic in that it is impossible to sufficiently inhibit the respective variations of deposition rates & compositions of films. Since the constituent particles also become scattered away from the substrate, furthermore, the consumption of the target is profuse, which is problematic not only because the production efficiency becomes inferior but also become the production cost becomes high. [0004]

The objective of the present invention, which has been conceived in acknowledgment of the above-mentioned problems inherent in the prior art, is to realize a sputtering device capable, by stabilizing deposition rates & compositions of films, of forming films in a high efficiency & at a low cost.

[0005]

(Mechanism for solving the problems)

The sputtering device of the present invention is a sputtering device designed, by oppositionally configuring a substrate & a target and by depositing, onto said substrate, constituent particles released from said target, to form a film and is characterized by the configuration of a variable mechanism designed to mount the aforementioned target for rendering the distance & angle of the aforementioned target in relation to the substrate to be adjustable. [0006]

In this case, it is also conceivable for multiple targets to be configured in opposition to said substrate and for at least one of said targets to be mounted on an individually configured variable mechanism.

[0007]

(Functions)

It becomes possible, by thus configuring a variable mechanism, to adjust the distance & angle of a target in relation to a substrate in accordance with the changing flight pattern of constituent particles in the course of film formation actions, and accordingly, the deposition rate & composition of a film formed adventitiously on the substrate can be matched with their counterparts in the initial phase of the film formation actions.

[0008]

(Application examples)

Next, application examples of the present invention will be explained with reference to figures.

[0009]

Figure 1 is a diagram which shows the constitution of the first application example of the sputtering device of the present invention. [0010]

According to the present application example, two types of targets yielding constituent particles bearing mutually different flight patterns are installed within a singular film formation chamber, whereas a film is designed to become formed above a substrate by constituent particles sputtered from the respective targets. [0011]

A first target (102) & a second target (103) are configured in opposition to a substrate (110) within a film formation chamber (101). The first target (102) & second target (103) are connected respectively to a first power source (105) & a second power source (106), whereas constituent particles become scattered from the respective targets upon the reception thereby of electric powers fed from the respective power sources, as a result of which a film becomes formed. As the first & second targets of the present application example, a target yielding, in the course of film formation, scattered constituent

particles destined predominantly along a direction perpendicular to the target surface is used as the first target, whereas a target yielding particles destined predominantly along a diagonal direction is used as the second target. For this reason, the second target (103) is mounted on a variable mechanism (104) capable of arbitrarily adjusting the distance & angle in relation to the substrate (110). [0012]

The atmosphere within the film formation chamber (101) is controlled by a vacuum valve (107), a gas purging mechanism (108) designed to purge, via the vacuum valve (107), the interior of the film formation chamber (101), and a gas introduction valve (109) designed to feed a specified gas into the film formation chamber (101).

[0013]

Next, concrete examples of film formation actions executed by the sputtering device shown in Figure 1 will be explained. [0014]

Concrete Example 1: A perpendicularly magnetized film was formed by using the sputtering device shown in Figure 1. An iron-cobalt alloy was used as the first target (102), whereas terbium was used as the second target (103), whereas a substrate (110) made of a glass was installed. The film formation chamber (101) was subsequently purged by the gas purging mechanism (108) till the achievement of 1×10^{-7} Torr. Next, gaseous Ar was introduced, via the gas introduction valve (109), as a sputter gas till the pressure within the film formation chamber (101) had reached 2×10^{-3} Torr. Specified electric powers were subsequently impressed from the first power source (105) & second power source (106) respectively onto the first target (102) & second target (103), as a result of which a terbium-

/3

iron-cobalt film was formed above the substrate (110) at an eventual thickness of 2,000 Å. The leak of the film formation chamber (101) was subsequently induced, and after the substrate (110) had been retrieved, the terbium atom concentration within the film was measured by using a fluorescent X-ray analyzer. [0015]

Figure 2 & Figure 3 respectively show temporal variations of the terbium atom

concentration & film thickness of a case where the film formation action was repeatedly invoked, whereas the respective figures show the variations of the film quality & film formation rate. [0016]

In each figure, the line segment (a) expressed by an unbroken line shows the temporal variation of a case where adjustments are adventitiously rendered by the variable mechanism (104) in such a way that constituent particles scattered from the second target (103) will be destined toward the substrate (110), whereas the line segment (b) expressed by

a broken line shows the temporal variation of a case where the variable mechanism (104) is fixed.

[0017]

The terbium atom concentration shown in Figure 2 gradually decreases in a case where the variable mechanism (104) is fixed, as the line segment (b) indicates, in contrast with which a constant concentration can, as the line segment (a) indicates, be maintained by adjusting the flight directions of constituent particles scattered from the second target (103) by using the variable mechanism (104). [0018]

The film formation rate shown in Figure 3 gradually decreases in a case where the variable mechanism (104) is fixed, as the line segment (b) indicates, in contrast with which a constant rate can, as the line segment (a) indicates, be maintained by adjusting the flight directions of constituent particles scattered from the second target (103) by using the variable mechanism (104). [0019]

It thus becomes possible, according to the present application example, to stabilize the deposition rates & compositions of films by adjusting the distance & angle of the target in relation to the substrate. Moreover, since the constituent particles can be scattered exclusively toward the substrate, it becomes possible to inhibit the target consumption and to depreciate the substrate production cost. [0020]

Figure 4 shows temporal variations of terbium atom concentrations in a case where the aforementioned film formation actions of the sputtering device shown in Figure 1 are invoked by varying the installation position of the substrate (110). In Figure 4, as in Figure 2 & Figure 3, the line segment (a) expressed by an unbroken line shows the temporal variation of a case where adjustments are rendered by the variable mechanism (104) in such a way that constituent particles scattered from the second target (103) will be destined toward the substrate (110), whereas the line segment (b) expressed by a broken line shows the temporal variation of a case where the variable mechanism (104) is fixed.

[0021]

The terbium atom concentration gradually increases in a case where the variable mechanism (104) is fixed, as the line segment (b) indicates, in contrast with which a constant concentration can, as the line segment (a) indicates, be maintained by adjusting the flight directions of constituent particles scattered from the second target (103) by using the variable mechanism (104). [0022]

Concrete Example 2: A dysprosium-iron-cobalt film was formed at an eventual thickness of 2,000 Å by using dysprosium as the second target (103) in the sputtering device shown in Figure 1 under conditions otherwise utterly identical to those in Application Example 1. The leak of the film formation chamber (101) was subsequently induced, and after the substrate (110) had been retrieved, the dysprosium atom concentration within the film was measured according to procedures similar to those in Application Example 1. [0023]

Figure 5 shows temporal variations of the dysprosium atom concentrations of a case where the film formation action was repeatedly invoked, whereas this figure shows the variations of the film quality. [0024]

In the figure, the line segment (a) expressed by an unbroken line shows the temporal variation of a case where adjustments are rendered by the variable mechanism (104) in such

a way that constituent particles scattered from the second target (103) will be destined toward the substrate (110), whereas the line segment (b) expressed by a broken line shows the temporal variation of a case where the variable mechanism (104) is fixed.

[0025]

The dysprosium atom concentration shown in Figure 5 gradually decreases in a case where the variable mechanism (104) is fixed, as the line segment (b) indicates, in contrast with which a constant concentration can, as the line segment (a) indicates, be maintained by adjusting the flight directions of constituent particles scattered from the second target (103) by using the variable mechanism (104).

[0026]

Concrete Example 3: Figure 6 is a diagram which shows the constitution of the second application example of the present invention. [0027]

A film was formed by using the sputtering device & alloy target shown in Figure 6 according to procedures otherwise similar to those in Application Example 1. [0028]

According to the present application example, an alloy target is installed within a film formation chamber, whereas a film is formed above a substrate by constituent particles scattered from said target. [0029]

A target (602) comprising of a terbium-iron-cobalt alloy is configured in opposition to the substrate (610) within a film formation chamber (601). The target (602) is connected to a power source (605), whereas constituent particles become scattered from the power source (605) upon the reception thereby of an electric power fed from said target (605) [sic: Presumably "(602)"], as a result of which a film becomes formed. Since the target (605) [sic] is a terbium-iron-cobalt alloy, mutually different types of constituent particles become scattered in relation to the substrate according to mutually different flight patterns. These flight patterns of the respective constituent particles vary in the course of the film formation actions, and therefore, the target (603) [sic: Presumably "(602)"] is installed above a

variable mechanism (604) capable of arbitrarily adjusting the distance & angle in relation to the substrate (610). The atmosphere within the film formation chamber (601) is, as in the embodiment shown in Figure 1, controlled by a vacuum valve (607), a gas purging mechanism (608) designed to purge, via the vacuum valve (607), the interior of the film formation chamber (601), and a gas introduction valve (609) designed to feed a specified gas into the film formation chamber (601). [0030]

Figure 7 shows temporal variations of the terbium atom concentrations of a case where the film formation action is repeatedly invoked, whereas this figure shows the variations of the film quality. [0031]

In the figure, the line segment (a) expressed by a broken line shows the temporal variation of a case where the target (602) is adjusted by the variable mechanism (604) in accordance with the variations of the scattering directions of the respective constituent particles, whereas the line segment (b) expressed by an unbroken line shows the temporal variation of a case where the respective planes of the target (602) & substrate (610) are fixed at a constant non-parallel angle by the variable mechanism (604), whereas the line segment

(c) expressed by a single-dot chain line shows the temporal variation of a case where the respective planes of the target (602) & substrate (610) are fixed in parallel to one another by the variable mechanism (604).

[0032]

The terbium atom concentration gradually decreases in a case where the respective planes of the target (602) & substrate (610) are fixed in parallel to one another, as the line segment (c) indicates, in contrast with which a constant concentration can, as the line segment (a) indicates, be maintained by adjusting the target (602) with the variable mechanism (604). In a case where the respective planes of the target (602) & substrate (610) are fixed at a constant non-parallel angle by the variable mechanism (604),

furthermore, the terbium concentration within the film decreases, although since the loss ratio is mitigated in comparison with the case where the same are fixed in parallel, the product yield can be improved.

[0033]

Concrete Example 4: Figure 8 is a diagram which shows the constitution of the third application example of the present invention. [0034]

A film was formed by using the sputtering device shown in Figure 8 according to procedures otherwise similar to those in Application Example 1. [0035]

According to the present application example, three targets yielding constituent particles bearing mutually different flight patterns are installed within a singular film formation chamber, whereas a film is formed above a substrate by the constituent particles scattered from the respective targets. [0036]

A first target (802), a second target (803), and a third target (811) are configured in opposition to a substrate (810) within a film formation chamber (801). The first target (802), second target (803), & third target (811) are connected respectively to a first power source (805), a second power source (806), & a third power source (813), whereas constituent particles become scattered from the respective targets upon the reception thereby of electric powers fed from the respective power sources, as a result of which a film becomes formed above the substrate (810). As the first through third targets of the present application example, a target yielding, in the course of film formation, scattered constituent particles destined predominantly along a direction perpendicular to the target surface is used as the first target, whereas targets yielding particles destined predominantly along diagonal directions are used as the second & third targets. The second target (803) & third target

(811) are therefore installed respectively above a first variable mechanism (804) & a second

variable mechanism (812) each capable of arbitrarily adjusting the distance & angle in relation to the substrate (810).

[0037]

The atmosphere within the film formation chamber (801) is, as in the respective embodiments shown in Figure 1 & Figure 6, controlled by a vacuum valve (807), a gas purging mechanism (808) designed to purge, via the vacuum valve (807), the interior of the film formation chamber (801), and a gas introduction valve (809) designed to feed a specified gas into the film formation chamber (801). [0038]

A film was formed by using terbium, iron, & cobalt respectively as the first target (802), second target (803), & third target (811) within the sputtering device shown in Figure 8 according to procedures otherwise similar to those in Application Example 1.

[0039]

Figure 9 & Figure 10 respectively show temporal variations of the terbium atom concentration & iron atom concentration of a case where the film formation action was repeatedly invoked, whereas these figures show variations of the film quality. [0040]

In each figure, the line segment (a) expressed by an unbroken line shows the temporal variation of a case where adjustments are rendered by the variable first variable mechanism (804) & second variable mechanism (812) in such a way that constituent particles scattered respectively from the second target (803) & third target (811) will be destined toward the substrate (810), whereas the line segment (b) expressed by a broken line shows the temporal variation of a case where the variable first variable mechanism (804) & second variable mechanism (812) are fixed.

[0041]

Both the terbium atom concentration shown in Figure 9 and the iron atom concentration shown in Figure 10 gradually decrease in a case where the first variable mechanism (804) & second variable mechanism (812) are fixed, as the line segment (b)

indicates, in contrast with which a constant concentration can, as the line segment (a) indicates, be maintained by adjusting the flight directions of constituent particles scattered respectively from the second target (803) & third target (811) by using the first variable mechanism (804) & second variable mechanism (812). [0042]

It becomes possible, according to the present application example, to individually adjust the respective distances & angles of the second target (803) & third target (811) in relation to the substrate (810) and accordingly to further improve the stability of the film quality. The film formation rate, furthermore, was similarly profiled, though not shown in figures. [0043]

Incidentally, no particularly detailed explanations have been provided concerning the structures of variable mechanisms of the respective application examples explained above, although there are no special restrictions on their structures, and a structure supported by three elastically deformable drive mechanisms, a triaxially rotatable stage, etc. are also conceivable.

[0044]

(Effects of the invention)

It becomes possible, according to the constitutions of the present invention explained above, to achieve the effects listed below.

[0045]

It becomes possible, according to the constitution mentioned in Claim 1, to match the deposition rate & composition of a film formed adventitiously on a substrate with their counterparts in the initial phase of the film formation actions by adjusting the distance & angle of a target in relation to said substrate, based on which effects of stabilizing the film deposition rate & composition and of forming a film in a high efficiency at a low cost can be achieved. [0046]

It becomes possible, according to the constitution mentioned in Claim 2, to adjust the respective distances & angles, in relation to a substrate, of multiply configured targets, based on which effects of further improving the aforementioned effects can be achieved.

Brief explanation of the figures

Figure 1: A diagram which shows the constitution of the first application example of the present invention.

Figure 2: A diagram which shows film quality variations of the first application example.

Figure 3: A diagram which shows film formation rate variations of the first application example.

Figure 4: A diagram which shows film quality variations of a case where the position of the substrate (110) shown in Figure 1 has been varied.

Figure 5: A diagram which shows film quality variations of a case where the type of the second target (103) shown in Figure 1 has been varied.

Figure 6: A diagram which shows the constitution of the second application example of the present invention.

Figure 7: A diagram which shows film quality variations of the second application example.

Figure 8: A diagram which shows the constitution of the third application example of the present invention.

Figure 9: A diagram which shows film quality variations of the third application example.

Figure 10: Another diagram which shows film quality variations of the third application example.

(Explanation of notations) (101), (601), & (801): Film formation chamber;

(102) & (802): First targets;

(103) & (803): Second targets;

(104) & (604): Variable mechanisms;

(105) & (805): First power sources;

(106) & (806): Second power sources;

(107), (607), & (807): Vacuum valves;

(108), (608), & (808): Gas purging mechanisms;

(109), (609), & (809): Gas introduction valves;

(110), (610), & (810): Substrates;

(602): Target;

(605): Power source;

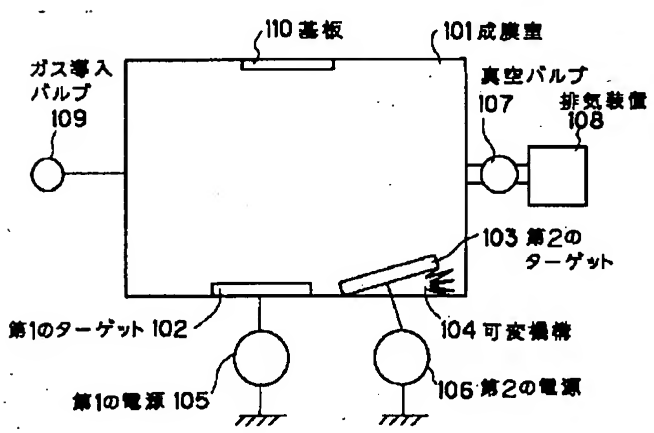
(804): First variable mechanism;

(811): Third target;

(812): Second variable mechanism;

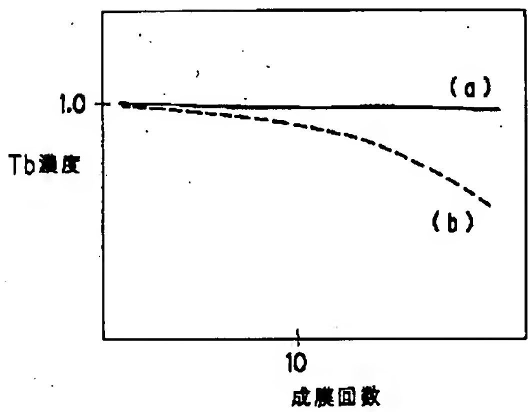
(813): Third power source.

Figure 1



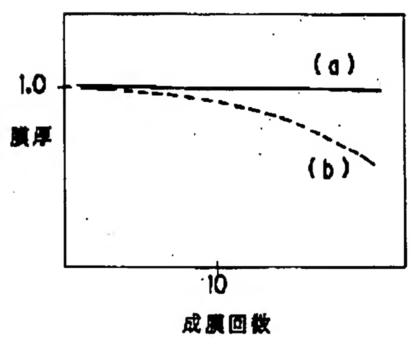
(101): Film formation chamber; (102): First target; (103): Second target; (104): Variable mechanism; (105): First power source; (106): Second power source; (107): Vacuum valve; (108): Gas purging mechanism; (109): Gas introduction valve; (110): Substrate]

Figure 2

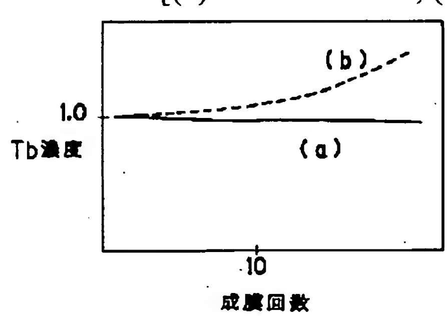


[(1): Tb concentration; (2): Number of film formation cycles]

Figure 3

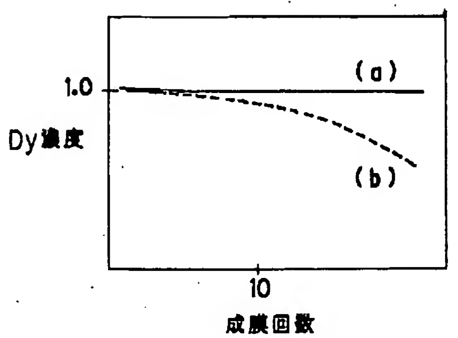


[(1): Film thickness; (2): Number of film formation cycles] Figure 4



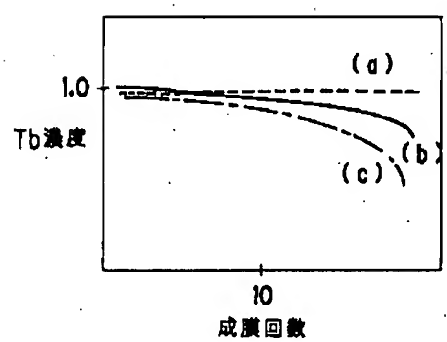
[(1): Tb concentration; (2): Number of film formation cycles]

Figure 5



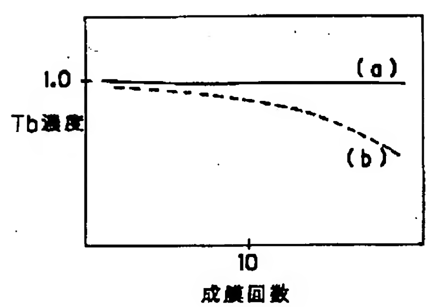
[(1): Dy concentration; (2): Number of film formation cycles]

Figure 7



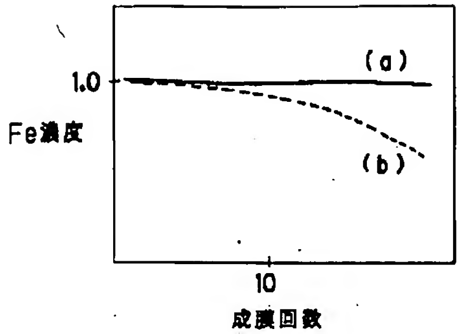
[(1): Tb concentration; (2): Number of film formation cycles]

Figure 9



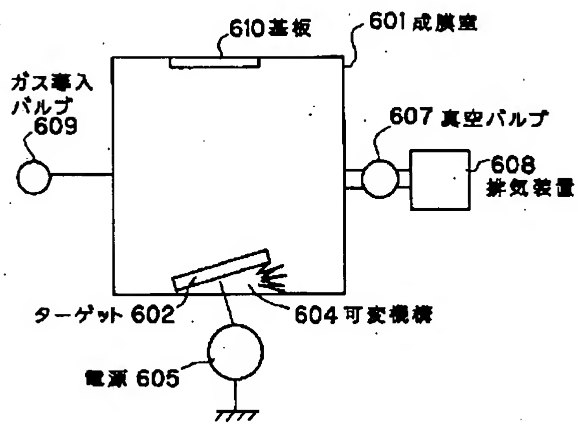
[(1): Tb concentration; (2): Number of film formation cycles]

Figure 10



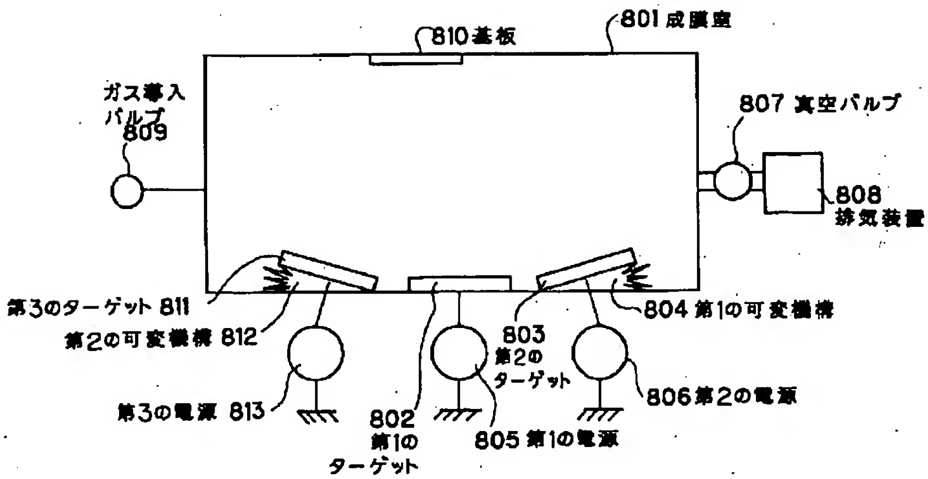
[(1): Fe concentration; (2): Number of film formation cycles] 6

Figure 6



[(601): Film formation chamber; (602): Target; (604): Variable mechanism; (605): Power source; (607): Vacuum valve; (608): Gas purging mechanism; (609): Gas introduction valve; (610): Substrate]

Figure 8 [(601): Film formation chamber; (802): First target; (803): Second target; (804): First variable mechanism; (805): First power source; (806): Second power source; (807): Vacuum valve; (808): Gas purging mechanism; (809): Gas introduction valve; (810): Substrate; (811): Third target; (812): Second variable mechanism; (813): Third power source]


810基板
801成膜室
ガス導入
バルブ
809
807 真空バルブ
808
排気装置
第3のターゲット 811
第2の可変機構 812
803
第2の
ターゲット
804 第1の可変機構
第3の電源 813
802
第1の
ターゲット
805 第1の電源
806第2の電源